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Data assimilation of remote sensing observations into hydrological models: challenges and perspectives in light of a new era of Earth observations

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Over the last 40 years remote sensing has significantly changed the way we observe and predict the Earth system, particularly in the oceanographic and meteorological sciences. Today, every General Circulation model (GCM) relies upon advanced and well-established data assimilation (DA) techniques, and Land Surface Models (LSMs) – which are integral components of GCM – have been increasingly using DA to constrain the LSM model predictions with available remote sensing data of hydrological, carbon and energy cycles.

Despite this, the use of DA into hydrological models (HMs) is still operationally limited and the reasons for that lie in 1) the considerable variability between different HMs, with much uncertainty in their respective representations of processes (often conceptual) and their sensitivity to changes in key variables, 2) the contrast between the scale of application of HMs (often smaller than LSMs) and the coarse-scale information provided by remote sensing along with their associated accuracy and, 3) the variety of the data assimilation setups, specificity of the study areas, and pre-processing used by a plethora of studies on the topic which provide a blurred picture on the real benefit of DA of relevant hydrological variables into HMs (e.g. soil moisture, precipitation, snow, terrestrial water storage anomalies).

The recent exponential grown of high-resolution remote sensing data (the European Union's Earth observation Programme Copernicus with the constellation of the Sentinel satellites is a notable example) has potentially opened new opportunities for improving our HMs also for small scale applications. However, their usefulness is still limited by our ability to analyse and integrate efficiently a large volume of observations with current hydrologic models. In other words, most of the issues mentioned above have been not overcome with a consequent under-exploitation of potentially useful information to constrain HMs.

This contribution aims to summarize the main challenges and opportunities of DA into HMs from a hydrological perspective in light of the availaiblity of new and more skillful Earth observations. It identifies and explains critical challenges by using published literature by the author on European catchments as well as on-going studies, and offers insights for a productive research based on new available models and observations as to build a comprehensive hydrologic data assimilation

framework that is a critical component of future hydrologic observation and modelling systems.